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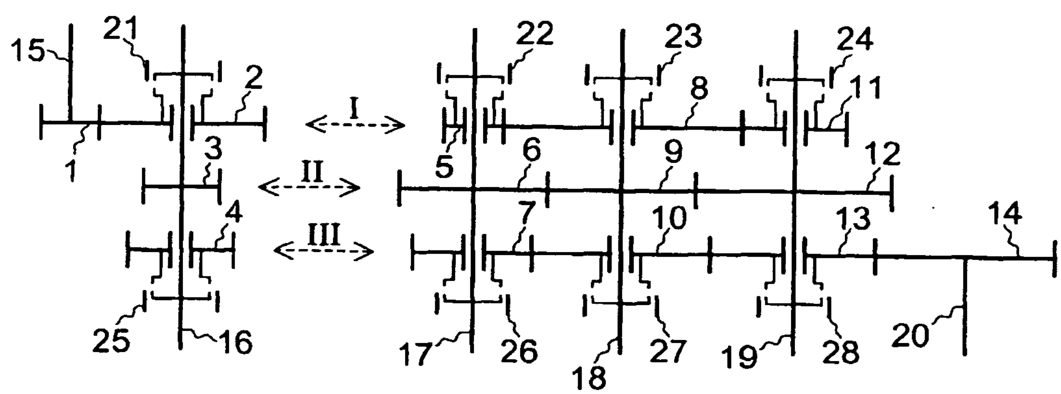

(57) Abstract: Method of construction of multi-speed motor vehicle gearboxes comprising several basic modules meshing in serial. A basic module is a set of three concentrical gear wheels (2-4) mounted in a shaft (16). One of those gear wheels is fixed to the shaft, while the others two gear wheels rotate freely on that shaft and can be coupled and uncoupled to that shaft by means of a conventional coupling system (21, 25). The basic modules are all meshed with each other's so that all the shafts must be parallel. The input gear wheel (1) meshes with a free gear wheel of any basic module and the output gear wheel (14) meshes with another free gear wheel of any basic module, with the condition that the input plane (I) where the input gear wheel meshes has to be a different plane (III) from that where the output gear wheel meshes.

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METHOD OF CONSTRUCTION OF MULTI-SPEED MOTOR VEHICLE GEARBOXES

The present invention relates to an innovating method of construction of multi-speed motor vehicle gearboxes, based in a new concept that is centralised in a gear basic module that are assembled and meshes in serial with one another, in order to perform a bigger number of gear transmission ratios, with a given number of gear wheels, of that it is allowed in the actual state of the art.

According to the present invention, for any set of gear wheels dimension used in the construction of the gearbox, the numerical results obtained for the final gear transmission ratios, after being sequentially ordered and disposed in a graph, lead to an irregular curve whose trend is exponential.

BRIEF DESCRIPTION OF THE RELATED STATE OF THE ART

The gearboxes used in the generality of motor vehicles are dimensioned in order to allow driving at different speeds, within the limits allowed by the capacity of the engine or imposed by driving conditions in the several types of applications. In this sense, the necessity of an increased number of the allowed gear transmission ratios of the gearboxes has been verified.

According to the actual related state of art, in the case of gearboxes constructed based on gear wheels and with a fixed integer number of gear transmission ratios, can be introduced a bigger number of gear transmission ratios assembling on the existent shafts a new pair of gear wheels, for each new speed transmission ratio added.

The gearboxes constructed according to this principle usually become lengthier and cause technical problems due to the lengthy of the shafts that contain the gear wheels. These technical problems have limited the maximum number of possible gear transmission ratios to a value of about six gear transmission ratios.

According to the actual related state of art, the diameter, or the tooth number, of each pair of gear wheels is designed in order to achieve a well-defined gear transmission ratio. In order to engage a new speed transmission ratio, it is necessary to uncouple from the shaft one gear wheel, of one pair of gear wheels, and to couple with the shaft another gear wheel of another pair of gear wheels.

BRIEF DESCRIPTION OF THE INVENTION

According to the present invention, instead of using several pairs of gear wheels assembled within parallel shafts, in order to accomplish the gear transmission ratios it is used several sets of three gear wheels mounted concentrically within a shaft.

Therefore, the fundamental innovation introduced by this invention in concerned to the, so called, basic module that multiplies the number of the speed transmission ratios.

According to the actual related state of art, the so called basic module is composed by a pair of gear wheel assembles within parallel shafts. Each pair of gear wheels corresponds to a transmission ratio and, therefore, the total number of possible gear transmission ratios is equal to the number of gear wheel pairs that have been used.

According to the present invention, the so called basic module is composed by a set of three concentrical gear wheels (2-4), of different dimensions, mounted in a shaft (16). One of these gear wheels is permanently fixed in that shaft (16), while the other two gear wheels can be coupled and uncoupled to that shaft by means of a conventional coupling and uncoupling system (21,25).

According to the present invention, the basic modules are added in serial and meshes one with the others. The number of the final gear transmission ratios is equal to the square of the number of basic modules used in the gearbox, meshing in serial.

For example, using four basic modules the total number of gear transmission ratios available will be sixteen. Using five basic modules the total number of gear transmission

ratios available will be twenty-five. Using six basic modules the total number of gear transmission ratios available will be thirty-six, and so on.

A basic characteristic of the gearbox constructed in accordance with the method defined by the present invention, consists in the fact that the set of multiple transmission ratios, after being sequentially ordered and plotted in a graph, it is always an irregular curve whose trend is exponential, or logarithmic, depending if the sequential order was made ascendant or descendant.

According to the present invention, in order to shift transmission ratios it is necessary to simultaneously uncouple two gear wheels and couple two gear wheels.

FIELD OF THE INVENTION

Gearboxes constructed in accordance with the present invention apply to all type of motor vehicles, when a gearbox capable to provide multiple speed transmission ratios is needed.

Due to the big number of speed transmission ratios, that are possible to achieve with this gearbox, and because it is necessary to uncouple and couple two gear wheels, in order to shift transmission ratios, it isn't considered possible to use a manual and mechanical engagement system for the gearbox, by means of a direct link to the vehicle interior.

In the case of this invention, in order to shift speed transmission ratios it must be used an electric, pneumatic or hydraulic actuation system, controlled by a computerised supervisor system.

The above characteristic of this invention leads to solutions that can be completely automatic for the actuation of the gearbox.

Because another important characteristic of this gearbox is the fact that the numerical solution obtained, after being conveniently ordered, is a curve whose trend is exponential, the biggest speed reduction are privileged with a bigger number of gear transmission ratios, corresponding to slow speeds of the vehicle.

Therefore, the present invention has special application in trucks and all kind of heavy vehicles, whose engine need to produce great efforts at vehicle low speed.

For other type of vehicles, like in the case of passenger cars, who usually do not need many speed transmission ratios, the great number of speed transmission ratios available by the present invention leads to the possibility of being able to select a proper scheduling of the gear transmission ratios, for all kind of uses, like for instance: driving in the city, on the road, in the high-way, on the mountain, with rain, snow or sand. Or, it is possible to define the use of the vehicle for a specific regimen, like for instance: performance and maximum power output, or a regimen of maximum fuel consumption economy.

AIM OF THE INVENTION

The present invention purposes four basic objectives.

The main objective is to increase significantly the number of possible speed transmission ratios of the gearboxes.

The second objective is the use, as much as possible, of the same components used in the conventional gearboxes. The present invention uses the same type of gear wheels of conventional gearboxes, with helical teeth in all the gear wheels, and it uses conventional systems for synchronism and coupling of gear wheels with the shafts.

The third objective obtained with this invention is the reduction of the efforts in gear wheels teeth and in the respective shafts. For the effect, in contrast with the actual state of the art, in the case of this invention the great majority of the gear wheels have two distinct contact points with the adjacent gear wheels. Therefore the teeth efforts in the gear wheel are divided by two teeth in each gear wheel. The length of the shafts that contain the gear wheels have been significantly reduced, compared to the habitual, and therefore the shafts have less bending efforts and the gear wheels meshing is more accurate.

The last objective achieved with this invention is the possibility of a reduction in the space used by the gearboxes. The present gearbox makes a better use of the space available in the

perpendicular direction of the engine shaft and reduces the length in the longitudinal direction of the engine. Therefore, the present gearboxes are specially indicated for use in vehicles with engine disposed transversally, as it is the case of the majority of the small automobiles currently existing in the market.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawings included in this patent of invention are a schematic examples of two possible configurations that the so called basic modules in serial can have, according with the rules and conditions explicit in the detailed description and claims further presented.

Because any type of practical solution for the present invention demands that the profile and dimensions of all the teeth, used in the gearboxes, must be rigorously equal in all gear wheels used, the diameter of the gear wheels must be compatible with the needed number of tooth necessary to manufacture in each of the gear wheels.

Therefore, for the elaboration of the drawings included in this patent of invention the number of the tooth has been rigorously fixed, for each of the gear wheels.

Fig.1 shows a highly schematic presentation of the basic working mechanism of a gearbox comprising four basic modules, one input gear wheel with shaft and one output gear wheel with shaft. One of the four modules is intentionally detached from the others in order to better define the so called basic module. Fig.1 is used do describe in detail the working mechanism of the present method of construction of multi-speed motor vehicle gearboxes.

Fig.2 shows the same gearbox of Fig.1 in another schematic view.

Fig.3 is related to the previous Fig.1 and Fig.2 and is included to show another possible distributions of the four basic modules, and another possible location of the input and output gear wheels, that leads to the same final results of that of the gearbox represented in Fig.1.

Fig.4 shows a highly schematic presentation of the working mechanism of one complete gearbox comprising six basic modules. Fig.4 is an example of a particular gearbox with thirty-six speed transmission ratios, for application in front transverse engine vehicles.

Fig.5-8 are related to the previous Fig.4. They are included to describe the real disposal of each component of the gearbox. Fig.5 shows the complete gearbox, with all parts assembled in the final position. Fig.6 shows a detail of the input plane (I) of the gearbox. Fig.7 shows a detail of the plane (II) of the gearbox and, finally, the Fig.8 shows a detail of the output plane (III) of the gearbox.

DETAILED DESCRIPTION OF THE INVENTION

Motor vehicle gearbox according to Fig.1-3, with multiple gear transmission ratios, comprising a serial association of several basic modules, with different diameters, one input gear wheel (1) and one output gear wheel (14).

Each one of the so called basic module is composed by three gear wheels (2-4), by one shaft (16) and by two conventional coupling and uncoupling systems (21,25), in order to couple and uncouple with the shaft (16) two gear wheels (2,4) that are free to rotate on the respective shaft (16). In each basic module the three gear wheels (2-4) are concentrical and concentrical with the shaft (16). In each basic module all the three gear wheels (2-4) have a different tooth number. In each basic module one and only one of the three gear wheels (2-4) must be rigidly fixed with the shaft (16). In each basic module there are two gear wheels (2,4), free to rotate on the shaft (16), that can be coupled and uncoupled to the shaft (16) by means of the related conventional coupling and uncoupling systems (21,25).

In the Fig.1 are schematically represented four basic modules. Also are represented the input gear wheel (1), rigidly fixed to the input shaft (15), and also are represented the output gear wheel (14), rigidly fixed to the output shaft (20). In Fig.1 one of the basic modules is intentionally detached from the others, in order to better define the basic module that is in the origin of the present invention.

The diameter of each gear wheel, of each of the basic modules, must be of form to allow to engage with the diameter of each corresponding gear wheel on the adjacent basic modules, with the condition that all the shafts of the basic modules must be parallel. In each basic

module, the gear wheel that is permanently fixed to the shaft meshes with the correspondent gear wheel fixed to the shaft in the following basic module.

The basic modules constructed by this method can be permanently meshed with each other's, in serial, and the sequential order of those basic modules can be modified without causing any changes to the final result.

The Fig. 2 and Fig.3 are based on Fig.1, but the disposal of the basic modules was intentionally modified to demonstrate that the order of the basic modules can be changed.

Fig.1-3 corresponds to the same gearbox and the numerical values of the final gear transmission ratios are the same, although the disposition of the basic modules have been changed between Fig.1-2 and Fig.3, as it is demonstrated bellow.

Between the Fig.1-2 and Fig.3 the position of the input gear wheel (1) and the position of the output gear wheel (14) were also modified. This alteration does not constitute any change to the numerical values of the final gear transmission ratios of the gearbox, also.

To demonstrate that none of the above mentioned alterations cause any changes to the final numerical results, it must be had in consideration that the transmission ratio between any two gear wheels results exclusively from the quotient of the primitive diameters of the two gear wheels, or the quotient of the tooth number of the two gear wheels. If between those two gear wheels exists one third gear wheel the result does not change. The mathematical demonstration is the following: let us consider three wheels of diameters D1, D2 and D3 and that the wheel D1 engages with the wheel D2, and the wheel D2 engages with the wheel D3; the transmission ratio between the wheel D1 and the wheel D3 is calculated as following: : $D1/D2 \times D2/D3 = D1/D3$. This concludes that the final transmission ratio between the wheels D1 and D3 does not depend on the diameter of the intermediate wheel D2. This demonstrations is valid for any number of wheels that exists engaged between the first and the last wheel: : $D1/D2 \times D2/D3 \times D3/D4 \times D4/D5 = D1/D5$.

Based on the previous demonstration, in the gearbox according to Fig.1 we can define the existence of three parallel planes (I-III), disposed in the perpendicular direction to the shafts (16-19), containing a group of gear wheels engaged and meshing in serial that have the

above property: the transmission ratio between any two gear wheel does not depend on the intermediate wheels. The plane (I) that contains the input gear wheel (1) is called input plane (I). The plane (III) that contains the output gear wheel (14) is called output plane (III).

According to the previous mathematical demonstration, one concludes that the input gear wheel (1) can mesh with any of the free gear wheels (2,5,8,11) of the input plane (I), on any of the basic modules, and the output gear wheel (14) can mesh with any of the free gear wheels (4,7,10,13) of the output plane (III), with the condition that the plane (I) where the input gear wheel (1) meshes has to be a different plane (III) where the output gear wheel meshes.

The input plane (I) is composed of the gear wheels (2,5,8,11) that are free to rotate on the respective shaft. Therefore, the gear wheels of the input plane (I) can rotate synchronised without transmitting movement to none of the shafts (16-19). In this conditions the gearbox is in death point.

The rotation speed of any of the gear wheels (2,5,8,11), of the input plane (I), is a function of the quotient between the diameter of the respective gear wheel, (2),(5),(8), or (11), and the diameter of the input gear wheel (1). Because the gear wheels (2,5,8,11) have all different diameters, they will rotate at different rotation speeds.

When one of the couplings (21-24) is performed, in any of the basic modules, the respective gear wheel, (2),(5),(8), or (11), transmits its rotation speed to the respective shaft, (16), (17),(18), or (19). That shaft, that has been coupled with one of the gear wheels (2,5,8,11), will have the rotation speed of the respective coupled gear wheel, (2),(5),(8), or (11).

All of the basic modules have a gear wheel (3,5,9,12) rigidly fixed to the shaft (16-19) in the plane (II) that directly receives the rotation speed of the shaft. That gear wheel, (3), (6), (9), or (12), that received the rotation speed of the respective shaft, will have the new function of input gear wheel to the movement of the gear wheels within plane (II).

Departing from that new input gear wheel for the plane (II), the rotation speed of any of the gear wheels (3,6,9,12) will be a function of the quotient between the diameter of each one of them, (3),(6),(9), or (12), and the diameter of the mentioned new input gear wheel.

Because the gear wheels of the basic modules have different diameters, the rotation speed of each one of the gear wheels, (3),(6),(9), or (12), will be different, function of the gear wheel, (2),(5),(8), or (11) coupled with the respective shaft (16-19) in plane (I).

In the case of the gearbox of Fig.1, because there are four basic modules, there are four possibilities of coupling in the plane (I). Therefore, the set of the four gear wheels (3,6,9,12), rotating synchronised within plane (II), can have four different rotation speeds. For example, the gear wheel (6) can have four different rotation speeds, as much as the number of basic modules within the gearbox.

In the output plane (III) exists another set of gear wheels (4,7,10,13), free to rotate on the respective shaft (16-19), that have a coupling and uncoupling system (25-28) with the respective shafts (16-19).

The next step, in order to the movement being transmitted to the output gear wheel (14) of the gearbox, consists on coupling one of those gear wheels, (4),(7),(10), or (13), within the output plane (III), with any of the respective shafts, by means of the respective coupling system (25-28).

The gear wheel, (4),(7),(10), or (13), of the output plane (III), that will be coupled with the respective shaft, (16),(17),(18), or (19), will receive the rotation speed of that shaft. Therefore, the rotation speed of that shaft is the new input rotation speed for the output plane (III).

Departing from that new input rotation speed of one of the shafts (16-19), the rotation speed of each of the gear wheels (4,7,10,13), of the output plane (III), will be function of the quotient between the diameter of the respective gear wheel, (4),(7),(10), or (13), and the diameter of the gear wheel, within the output plane (III), that has been coupled in that output plane (III).

In the case of the gearbox of Fig.1 there are four possibilities of coupling in the output plane (III), with any of the four shafts (16-19). Because any of those four shafts (16-19) have a different rotation speed and because any of those individually shafts can have also

another four different rotation speed, as were demonstrated previously, in the total there are sixteen possible rotation speeds for each of the gear wheels within the output plane (III).

Finally, the output gear wheel (14) is meshed with any one of the gear wheels (4,7,10,13), within the output plane (III), and receives the movement of that gear wheel to transmit it to the output shaft (20).

In accordance to the previous description, actuating one and only one of the coupling systems (21-24), within the input plane (I), and actuating one and only one of the coupling systems (25-28) existing in the output plane (III), a movement transmission exists between the input shaft (15) and the output shaft (20) of the gearbox.

The gearbox of Fig.1 has four basic modules and, in accordance to the previous definition of basic module, there are four coupling possibilities in the input plane (I), plus another four coupling possibilities in the output plane (III). Therefore, the total number of possible coupling combinations between the input and output planes are sixteen, as many as the total gear transmission ratios available for the gearbox in accordance to Fig.1.

In accordance to the previous description, one can verify that for a gearbox composed of any indeterminate number of basic modules, the total number of gear transmission ratios is equal to the square of the number of basic modules that the gearbox has. For example, a gearbox with three basic modules will have nine transmission ratios; a gearbox with five basic modules will have twenty-five transmission ratios, and so on.

In accordance to the previous description, one can verify that it is not necessary that the set of gear wheels rigidly fixed to the shaft exists in the central plane, and that the set of free gear wheels exists in the exterior planes, as schematised in Fig.1. The relative positions of those planes (I-III) can be changed, if the following condition are fulfilled: the input gear wheel (1) must engage in a plane with gear wheels that are free to rotate on the shaft; the output gear wheel (14) must engage in a plane with gear wheels that are free to rotate on the shaft; the plane where the input gear wheel (1) meshes must be a different plane of the plane where the output gear wheel (14) meshes.

DESCRIPTION OF FIG.4-8

The detailed description according to fig.1-3, previously presented, describes the present invention according to the Claims further presented. The description of Fig.4-8 presented here is just a description of a particular application to this invention, related to a gearbox with thirty-six transmission ratios, that although to be in accordance with the further Claims it is not considered the aim of this invention, because it is just a particular case.

The drawings of Fig.4-8 all relates to the same gearbox. The example of Fig.4-8 was chosen because it is a complete application and because it has some significant technical advantages, compared to other possible applications that use a small number of basic modules and also transmission ratios. The inclusion of this example is necessary to describe the method to execute the reverse speed in gearboxes constructed in accordance to the present invention.

The gearbox described in accordance to fig.4-8 corresponds to a gearbox with six gear basic modules and, in accordance to the Claims further presented, this gearbox performs thirty-six gear transmission ratios. The use of six basic modules has an additional advantage that consists on the possibility of the last basic module to mesh with the first basic module, describing a circle of basic modules as it is evidenced in Fig.5-8.

This advantage allows that all the gear wheels divide the effort transmitted by its teeth at least by two distinct teeth, thus theoretically reducing the effort of each tooth by half when compared to the actual state of the art. This advantage allows to reduce the dimension of the teeth and to increase the durability and reliability of the gear wheels.

In accordance to the example of Fig.4-8, the thirty-six speed gearbox comprises an input gear wheel (1) rigidly fixed to the input shaft (15), receiving movement from the engine shaft through a conventional clutch system (45), schematically represented in Fig.4.

The input gear wheel (1) meshes simultaneously with three gear wheels (2,8,29) and split the effort of the engine load by those three gear wheels (2,8,29). The gear wheels (2,8,29) transmit the movement to the set of six gear wheels (2,5,8,11,29,32), free to rotate on the respective shafts (16-19,37,38), and define the so called input plane (I). The six gear wheels (2,5,8,11,29,32), of the input plane (I), possesses a coupling and uncoupling system

(21-24,40,41) to the respective shafts (16-19,37,38).

In total there are seven gear wheels (1,2,5,8,11,29,32) permanently meshed in the input plane (I) and rotating synchronised. These seven gear wheels (1,2,5,8,11,29,32) only transmit movement to one of the shafts (16-19,37,38), and for any gear wheel of the gearbox, if one of the coupling (21-24,40,41) is actuated. If none of the couplings (21-24,40,41) is actuated the gearbox is in the death point.

The rotation speed of any of the gear wheels (2,5,8,11,29,32), of the input plane (I), is a function of the quotient between the diameter of the respective gear wheel and the diameter of the input gear wheel (1). Because the gear wheels have all different diameters, they will have different rotation speeds.

When one of the couplings (21-24,40,41) is actuated, the respective gear wheel transmits its rotation speed to the respective shaft (16-19,37,38). Because all the shafts (16-19,37,38) have a gear wheel (3,6,9,12,30,33) rigidly fixed to them, in plane (II), that gear wheel will receive the rotation speed of the shaft.

In the case of the example of Fig.4-8, the gear wheels rigidly fixed to the respective shafts all exists in the plane (II) of the gearbox. Therefore, those six gear wheels (3,6,9,12,30,33), of the plane (II), will receive the rotation speed of the shaft that has been coupled with one of the gear wheels (2,5,8,11,29,32) in the input plane (I).

The shaft that has been coupled with one of the gear wheels (2,5,8,11,29,32), in the input plane (I), will have the rotation speed of the respective gear wheel that has been coupled in the input plane (I). In the plan (II), the rotation speed of any of the gear wheels (3,6,9,12,30,33) will be a function of the quotient between the diameter of the respective gear wheel, (3),(6),(9),(12),(30), or (33), and the diameter of the gear wheel in plane (II) corresponding to the shaft that have been coupled in the input plane (I).

In the case of Fig.4-8, in the central plane (II) there is an additional gear wheel (35). The gear wheel (35) belongs to the reverse system and it does not participate in the execution of the thirty-six transmission ratios ahead. The function of this additional gear wheel (35) will be described later.

The next step, in order to the movement being transmitted to the output shaft (20) of the gearbox, consists on coupling one of the six gear wheels, (4,7,10,13,31,34), within the so called output plane (III), with any of the respective shafts (16-19,37,38), by means of one of the respective coupling system (25-28,42,43).

The gear wheel (4,7,10,13,31,34), of the output plane (III), that will be coupled with the respective shaft (16-19,37,38) will receive the rotation speed of that shaft. The rotation speed of each of the gear wheels (4,7,10,13,31,34), of the output plane (III), will be function of the quotient between the diameter of the respective gear wheel, (4),(7),(10),(13),(31) or (34), and the diameter of the gear wheel within the output plane (III) that has been coupled in that output plane (III).

Finally, the output gear wheel (14) is meshed with the gear wheels (13,34), within the output plane (III), and receives the movement of the output plane (III) to transmit it to the output shaft (20).

In the example of Fig. 4-8, the output shaft incorporates a conventional differential system (46). The dimension of the gear wheel (14) have to be dimensioned in order to execute the final transmission reduction to the wheels of the vehicle. Therefore, the example in accordance to Fig.4-8 corresponds to a gearbox with application to vehicles with transverse engine.

The output gear wheel (14) can mesh simultaneously with two gear wheels (13,34) of different diameter, because those gear wheels (13,34) have the same sense of rotation and because the multiplication between the diameter of the gear wheel (13) times is own rotation speed is equal to the multiplication of the diameter of the gear wheel (34) times is own rotation speed. The same happens for any of the six gear wheels (4,7,10,13,31,34) of the six basic modules existing in the output plane (III).

Therefore, the gear transmission ratio between any of the six gear wheels (4,7,10,13,31,34) and the output gear wheel (14) will be always the same, whatever the chosen gear wheel (4,7,10,13,31,34). The fact allows a great flexibility in terms of the drawing of gearboxes.

In accordance to the previous description, actuating one and only one of the coupling systems (21-24,40,41), within the input plane (I), and actuating one and only one of the coupling systems (25-28,42,43) existing in the output plane (III), a movement transmission exists between the input shaft (15) and the output shaft (20) of the gearbox.

Because there are six coupling possibilities in the input plane (I), plus another six coupling possibilities in the output plane (III), the total number of possible coupling combinations are thirty-six, as many as the total gear transmission ratios available for the gearbox in accordance to Fig.4-8.

For the elaboration of the drawings of Fig.4-8, it was established that the input gear wheel (1) has forty teeth and the gear wheels of the six basic modules have the tooth number indicate in table 1:

Table 1.

	Shaft (16)	Shaft (17)	Shaft (18)	Shaft 19	Shaft 37	Shaft 38
Input plane (I)	130 (2)	40 (5)	170 (8)	55 (11)	105 (29)	80 (32)
Plane (II)	90 (3)	80 (6)	130 (9)	95 (12)	65 (30)	120 (33)
Output plane (III)	70 (4)	100 (7)	110 (10)	115 (13)	45 (31)	140 (34)

Any gearbox constructed based on the method of the present invention and on the basis of the dimensions of the gear wheels presented in table 1, for the respective six basic modules, will have thirty-six transmission ratios in accordance to table 2.

The numerical values of table 2 correspond to the gear transmission ratios existing in the output plane (III) and correspond to the quotient between the rotation speed of an arbitrary chosen output gear wheel and the rotation speed of the input gear wheel (1). This before considering the final transmission reduction to the vehicle wheels. The final transmission reduction to the vehicle wheels is performed by the gear wheel (14), whose dimension is a function of vehicle type.

In the case, the arbitrary chosen output gear wheel was the gear wheel (7).

Table 2.

Order	Coupled shaft in plane (I)	Coupled shaft in plane (III)	Transmission ratio output/input	Reverse output/input
1ª	(37)	(37)	0,17143	0,2476
2ª	(16)	(37)	0,1917	0,2769
3ª	(37)	(16)	0,1926	0,2476
4ª	(37)	(18)	0,2095	0,2476
5ª	(18)	(37)	0,2118	0,3059
6ª	(16)	(16)	0,215	0,2769
7ª	(16)	(18)	0,234	0,2769
8ª	(18)	(16)	0,238	0,3059
9ª	(18)	(18)	0,259	0,3059
10ª	(37)	(38)	0,2889	0,2476
11ª	(37)	(19)	0,29975	0,2476
12ª	(37)	(17)	0,3095	0,2476
13ª	(16)	(38)	0,323	0,2769
14ª	(16)	(19)	0,3352	0,2769
15ª	(16)	(17)	0,346	0,2769
16ª	(18)	(38)	0,357	0,3059
17ª	(18)	(19)	0,3703	0,3059
18ª	(18)	(17)	0,382	0,3059
19ª	(38)	(37)	0,4154	0,6
20ª	(38)	(16)	0,467	0,6
21ª	(19)	(37)	0,47832	0,6909
22ª	(38)	(18)	0,508	0,6
23ª	(19)	(16)	0,5374	0,6909
24ª	(17)	(37)	0,5538	0,8
25ª	(19)	(18)	0,5846	0,6909
26ª	(17)	(16)	0,622	0,8
27ª	(17)	(18)	0,677	0,8
28ª	(38)	(38)	0,7	0,6
29ª	(38)	(19)	0,7263	0,6
30ª	(38)	(17)	0,75	0,6
31ª	(19)	(38)	0,8061	0,6909
32ª	(19)	(19)	0,83636	0,6909
33ª	(19)	(17)	0,8636	0,6909
34ª	(17)	(38)	0,933	0,8
35ª	(17)	(19)	0,9684	0,8
36ª	(17)	(17)	1	0,8

The output gear wheel (14) establishes with any of the gear wheels (4,7,10,13,31,34) of the output plane (III) a constant transmission ratio, any that will be the gear wheel, (4),(7),(10),(13),(31), or (34), chosen from the output plane (III), because the multiplication between the diameter of any of those gear wheel (4,7,10,13,31,34) times is own rotation speed is constant.

The gear box, in accordance to the drawings of Fig.4-8, also allows to perform six transmission ratios in reverse speed, although only two or three of those transmission ratios have practical utility in accordance to the previous table 2.

For the accomplishment of the reverse speed, the sense of rotation of the output gear wheel (14), and the sense of rotation of all the gear wheels within the output plane (III), must be reversed. For the effect two additional gear wheels (35,36) have been introduced in the gearbox, plus an additional shaft (39) and an additional coupling and uncoupling system (44), for the shaft (39) and the respective gear wheel (36).

In the example of Fig.4-8, the additional shaft (39) is concentrical with the input shaft (15). Both shafts rotate independently on the bearing (47), as indicated in Fig.4. The aim of this type of solution is to reduce the volume of the gearbox. However, this type of solution has a limiting disadvantage for the dimensions of the gear wheels (35,36) used for reversing.

For the accomplishment of the reverse speed, the additional gear wheel (36) meshes with the gear wheels (13,34), of the output plane (III), and rotates freely on the shaft (39). The additional gear wheel (35) meshes with the gear wheels (3,9,30), in the plane (II), and is rigidly fixed to the shaft (39).

The gear wheels (3,9,30) had been chosen because they allow the gear wheel (35), within plane (II), to rotate in reverse sense of the gear wheel (36) within output plane (III). Thus, when the gear wheel (36) is coupled with the respective shaft (39), by means of the coupling system (44), the sense of rotation of the gear wheels (4,7,10,13,31,34), within the output plane (III), is reversed, in order to accomplish the reverse speed.

In the case of the gearbox represented in Fig.4-8, whose final gear transmission ratios were shown in the previous table 2, the additional gear wheels (35,36) for the accomplishment of the reverse speed are equal and they have eighty teeth.

It is possible to perform six different transmission ratios in reverse speed because it is possible to carry through six different couplings of the gear wheels (2,5,8,11,29,32) within the input plane (I).

CLAIMS

Multi-speed motor vehicle gearbox, comprising:
a indeterminate number of basic modules of different diameters all assembled and meshed in serial; one input gear wheel (1); one output gear wheel (14);
the input gear wheel (1) is fixed to the input shaft (15) and the output gear wheel (14) directly transmits movement to the output shaft (20);
the so called basic modules are all meshed with each other's in a permanent way;
each one of the so called basic module is composed by three gear wheels (2-4), by one shaft (16) and by two conventional coupling and uncoupling systems (21,25), in order to couple and uncouple with the shaft (16) two gear wheels (2,4) that are free to rotate on the respective shaft (16); in each basic module the three gear wheels (2-4) are concentrical and concentrical with the shaft (16); in each basic module all the three gear wheels (2-4) have a different teeth number; in each basic module one and only one of the three gear wheels (2-4) must be rigidly fixed with the shaft (16); in each basic module there are two gear wheels (2,4) free to rotate on the shaft (16); in each basic module the two gear wheels (2,4), free to rotate on the shaft (16), can be coupled and uncoupled to the shaft (16) by means of the related conventional coupling and uncoupling systems (21,25);

2. Gearbox according to Claim 1, characterised in that the diameter of each gear wheel, of each of the basic modules, must be of form to allow to engage with the diameter of each corresponding gear wheel on the adjacent basic modules, with the condition that all the shafts of the basic modules must be parallel.

3. Gearbox according to Claims 1 and 2, characterised in that the gear wheel, of the basic modules, that is permanently fixed to the shaft meshes with the correspondent gear wheel fixed to the shaft in the following basic module.

4. Gearbox according to Claim 3, characterised in that the gear wheel that is permanently fixed to the shaft (16) can be any one of the three gear wheels (2-4) of the basic module.

5. Gearbox according to Claims 1-4, characterised for defining the existence of three parallel planes (I-III), disposed in the perpendicular direction to the shafts containing the

gear wheels of the basic modules; each one of those three parallel planes (I-III) is composed of a set of gear wheels permanently meshed between them; one of those planes contains the gear wheels that are fixed to the shafts, while the others two plans contain the wheels that are free to rotate on the respective shafts.

6. Gearbox according to Claims 1-5, characterised in that the input gear wheel (1) can be meshed with any gear wheel free to rotate on the respective shaft, of any of the basic modules, and characterised in that the output gear wheel (14) can be meshed with another gear wheel free to rotate on the respective shaft, of any of the basic modules, with the condition that the plane (I-III) where the input gear wheel (1) meshes must be a different plane (I-III) of the plane where the output gear wheel (14) meshes.

7. Gearbox according to Claims 1-6, characterised in that the transmissions shifts are performed, in any basic module, by means of simultaneously coupling with the respective shafts two gear wheels previously free to rotate on those same shafts, with the condition that those two free gear wheels to be coupled must not belong to the same plane (I-III); for the effect the related coupling and uncoupling systems are used for each one of the free gear wheels in cause.

8. Gearbox according to Claims 1-7, characterised in that the number of the final gear transmissions ratios is equal to the square of the number of the assembled basic modules the gearbox have, meshed in serial.

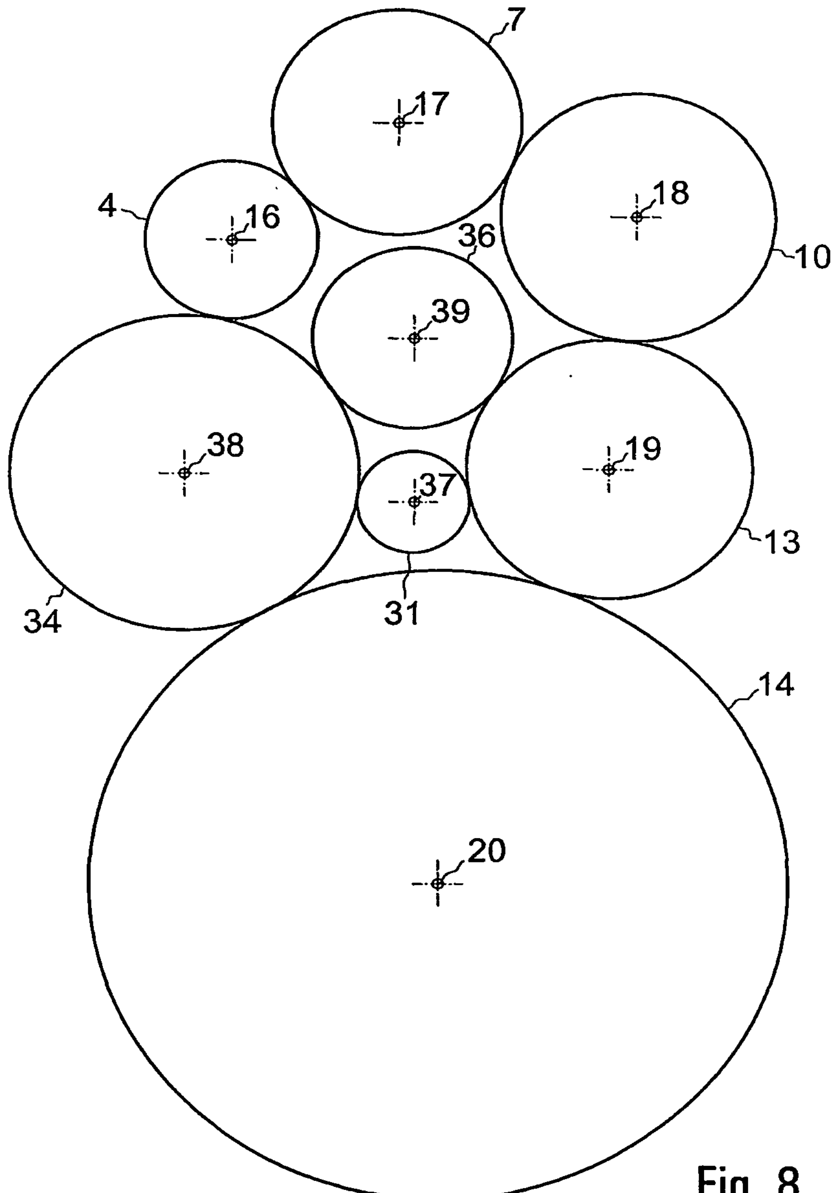

Fig. 8

INTERNATIONAL SEARCH REPORT

International Application No
PCT/PT 01/00009

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F16H3/093

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 F16H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 249 475 A (MCASKILL JOHN P) 5 October 1993 (1993-10-05) column 2, line 56 - line 68	1-5
X	US 4 392 391 A (JAMESON JAMES J ET AL) 12 July 1983 (1983-07-12) shaft 94; shaft 102 figure 3	1-5
A	US 5 063 793 A (MCASKILL JOHN P) 12 November 1991 (1991-11-12) figures	1
A	FR 2 591 300 A (PANHARD LEVASSOR CONST MECA) 12 June 1987 (1987-06-12) figures	1

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 December 2001	04/01/2002

Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

Inte   onal Application No
PCI/PT 01/00009

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 549 443 A (WHITE BASIL) 29 October 1985 (1985-10-29) figures -----	1

3

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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PCT/PT 01/00009

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